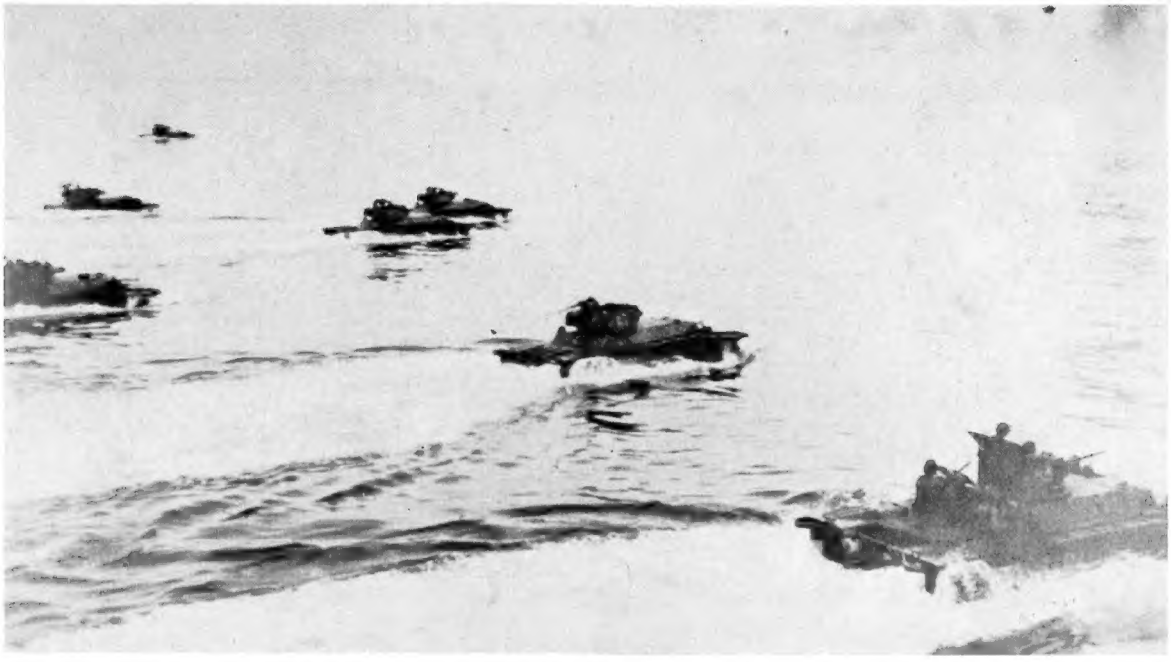
AFV 16

LANDING VEHICLES TRACKED

Successive waves of LVT 3s forming and moving shoreward at Iwo Jima. (Photo: U.S. Navy 50-G 312456)

Cover: *Marines coming ashore in and debarking from their LVT 2 at Namur in the Kwajalein Atoll, February 1944.*
(Photo: courtesy U.S. Marine Corps)

Beach installations at Iwo Jima and Amtrac casualties four days later already partially buried in the soft volcanic ash.
(Photo: U.S. Coast Guard)



The first wave of LVT (A) 1s and LVT (A) 4s moving toward the beach at Peleliu.

Landing Vehicles Tracked

by Robert J. Icks, Colonel USAR — Retired

PELELIU

ALTHOUGH the United States had naval bases in the Philippines and Hawaii in 1941, and in time of war expected to have access to British bases in Asia, there were no intermediate bases which could act as stepping stones to enable operations to be supported against an Asiatic enemy. World War II in the Pacific therefore became one of developing lines of communication which would continue to support operations against the Japanese as the line developed. Once a Japanese-held island was seized, it was exploited as a forward base for bombers and reconnaissance planes and sometimes as a full air or naval base to assist in holding those lines. The type of island landings the U.S. Marines and later the U.S. Army mounted in the Pacific was of necessity an amphibious assault defended by the enemy at the beach and it was at this point that the attacker was most vulnerable. The techniques worked out and exemplified by the time of the landing on Peleliu remained generally similar thenceforth in the Pacific.

LVTs were first used logistically in the Guadalcanal assault in August 1942 for carrying supplies from ship to shore. They were first used tactically in the landing at Tarawa in November 1943. The pattern established there continued to develop. Also, because of Tarawa, Navy airmen were "shocked into a better understanding of their air support mission" and naval gunfire in the future also was to improve.

An assault was planned against Peleliu for September 15, 1944 and, in spite of knowledge that over 10,000 Japanese were dug in there, only one division of Marines was available, partly because of overconfidence on the part of the division commander. Peleliu is a small coral island of about seven square miles, a part of the Palau group lying about 450 miles east of the Philippines. The southern part is relatively flat but has rugged coral outcroppings. The northern part is dominated by a jagged coral ridge about 550 feet in elevation, full of crags, escarpment and pinnacles. At the north tip is a mountain. Both the ridge and the mountain were honeycombed with caves and the Japanese had blasted out the coral to interconnect many of them. However, there was no advance intelligence of this. The ground was covered with thick scrub jungle with mangrove growth in the swamps. There are no rivers and the ground drains rapidly after rains.

It was decided to land on the southwest beaches because the flat terrain would permit tank and artillery employment. The 1st Marines supported by 15 medium tanks were to land on the left with two battalions in assault and one in reserve. The 5th Marines supported by nine medium tanks were to land on the center beach with two battalions in assault and one in support to land one hour later. Two battalions of the 7th Marines supported by six medium tanks were to land in columns on the right. One battalion of the regiment formed the division reserve. It was believed that Army troops in floating reserve also would be available if needed.

The 5th was to secure the airfield, the 1st was to wheel left and the 7th was to wheel right after landing. The attack was organized in waves, the first wave com-

The beach at Peleliu after the Beachhead had been established.

prising howitzer-armed LVT(A) 4s led in by rocket-firing gunboats. The other waves of LVTs carrying troops followed.

The troops came from widely separated points. The 1st Marines, for example, loaded at five different ports. Rehearsals thus could not be coordinated. Two battleships collided during a rehearsal and could not participate in the actual attack. Several other ships suffered collisions on the way. Because of the shortage of shipping, 16 of the 46 division medium tanks had to be left behind. All tanks had been waterproofed but some were diesel tanks just received and were new to the Marines.

The original LVT battalion was split to form two battalions and an additional provisional battalion was formed, adding vehicles and personnel as they became available from various sources. The officers were untrained in the use of LVTs and the enlisted men lacked combat experience. At the last minute, 50 new model LVTs or amtracs, as they were called, showed up.

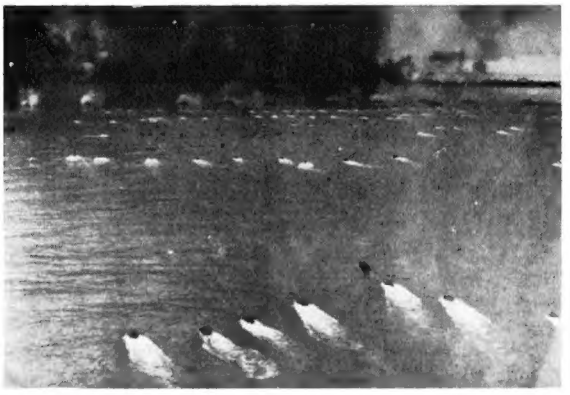
An innovation for this operation was the provision of three LVTs mounting Navy Mark I flamethrowers capable of firing a jet or "rod" of thickened fuel some 100 yards. The plans for Peleliu contemplated assigning one such vehicle to each assault regiment. The radio of each tractor was set on the regimental command frequency of the regiment which it was to support. They were to land just behind the wave of LVT(A) 1s leading the 1st Marines and with the first wave of the 5th Marines. That for the 7th Marines was to stand off shore with 12 LVT(A) 1s near a small island on the left flank, ready to follow in to the beach. There were two additional LVTs to service the flamethrower vehicles. One of these shipped water and sank three hours after the landing. The other came to the rescue but was unable to help.

LVT (A) 4s moving into the beach at Angaur Island as part of the first wave.

In the actual landing the plan for using these flamethrower vehicles broke down completely. The one with the 1st Marines stood by under fire on the beach for five hours waiting for orders from the regiment. The one with the 5th was ordered to stand off shore out of danger. After landing, all three stood by for the rest of the day. No use was made of them again on the second day. Beginning with the third day, they were assigned daily to the regiments and reported to their command posts to receive their instructions for each mission.

Another innovation at Peleliu was adopted as a result of previous tank casualties and landing delays. A letter from a Marine tank officer quoted in *Peleliu*, a Marine Corps combat monograph by Major Frank O. Hough, USMCR, described this as follows:

> "An LVT was placed on each LCT (Landing Craft, Tank) to lead the tanks ashore. These LVTs were used to test the depth of the water, and as long as they propelled themselves along the bottom the tanks would follow, but if the LVTs became waterborne the tanks would stop until the LVTs could reconnoiter a safe passage. . . . Fuel, ammunition and maintenance supplies were loaded on these LVTs which enabled the tank units to have a mobile supply dump available to them upon reaching the beach."



Pall of black smoke covers the beach during the aerial bombardment as the waves of LVTs move toward the beach. (Photo: U.S. Navy)

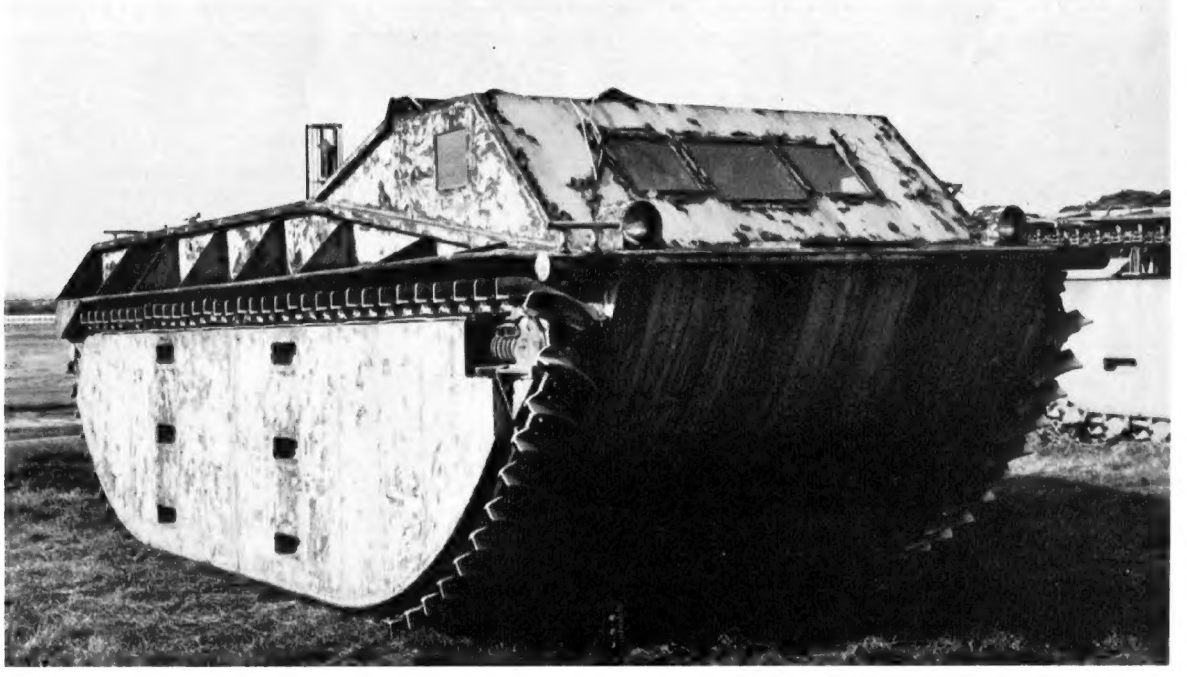
Knocked-out LVT 1 and LVT 2 on the beach at Tarawa following the initial assault. (Photo: U.S. Marine Corps)

After three days of naval bombardment, carrier planes strafed the beaches, moving ahead of the landing waves. Underwater demolition teams then moved in. By 7.15 a.m. on September 15, the LVTs arrived at the launching area. In spite of enemy fire from the moment it crossed the reef, the first wave reached shore, followed at five minute intervals by the succeeding waves. A quote from *The United States Marines and Amphibious War* by Peter A. Isely and Philip A. Crowl carries on the story:

". . . None of the amphibian vehicles was lost outside the reef line, but as succeeding waves crossed the reef they were met with steadily increasing enemy fire. The plan called for the armored amphibians to support the infantry inshore. Once ashore, however, armored vehicles encountered unexpected difficulties. Heavy mortar and gunfire covered the beaches, especially the flanks. Horned mines and buried 75 kilogram aircraft bombs were found in great quantities at the high water mark and caused quite a few casualties. An anti-tank ditch measuring about ten feet wide and eight feet deep extended along most of the beach front and seriously impeded all movement inland until routes around it could be found. As late as two hours after the initial landing the situation ashore was still so confused that it was virtually impossible for the armored amphibians to contact by radio the troops they were supposed to support. Casualties among all the amphibians, including DUKWs, were heavy throughout the day. The reef and beaches were quickly littered with disabled vehicles. The total amphibian tractor losses alone on September 15 amounted to twenty-six machines.

"Fortunately, the First Marine Division did not rely so heavily on armored amphibians to support the first waves of troops as had the Fifth Amphibious Corps on Saipan. During the latter operation, no

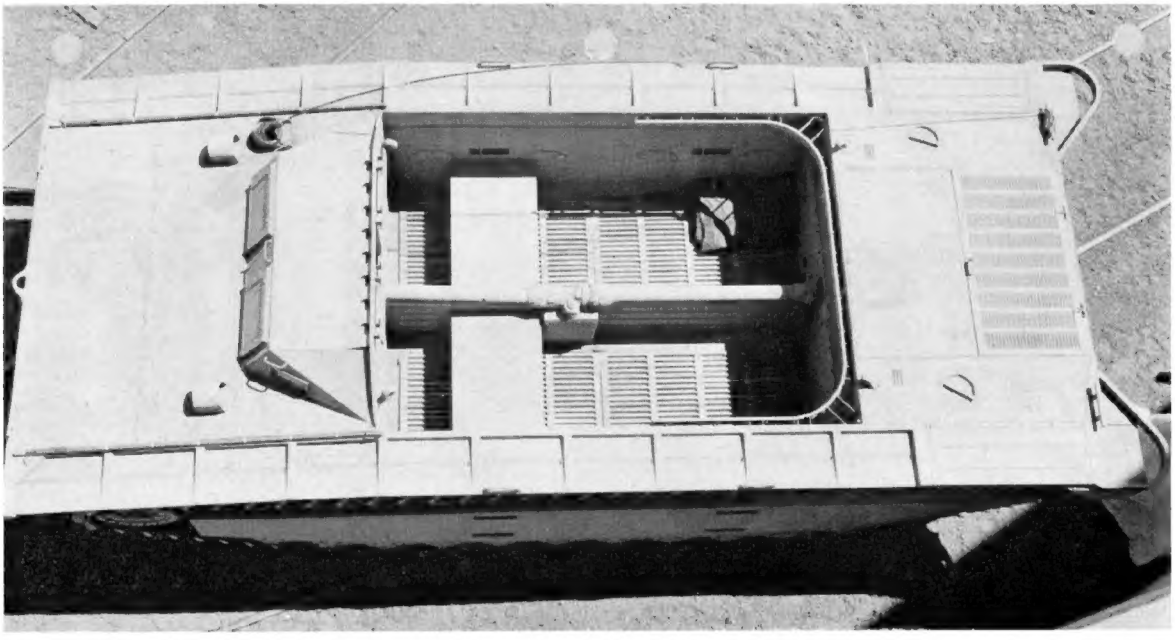
LVT 1 Prototype with the original track grousers which threw the water out and rearward. (Photo: courtesy G. B. Jarrett)



LVT 2 pulling two of the special amphibious trailers found so useful for carrying supplies. (Photo: Associated Press)

LVT 2 equipped with radio and showing bumper welded to bow. (Photo: courtesy C. J. Nuttall)

Top view of LVT 2 showing restricted size of interior with engine rear mounted. (Photo: courtesy C. J. Nuttall)



tanks were landed for more than an hour and a half after the first troops reached shore. At Peleliu, tanks were debarked at the reef's edge only twenty minutes after the first wave had landed. Thirty medium tanks with amphibian tractors to guide them proceeded across the broad fringing reef in six parallel columns of five tanks each. Each column was guided around boulders, potholes and bomb craters by its amphibian tractor guide. Due to the shallowness of the water inside the lagoon and the smoothness of the reef, all but three of the thirty tanks were able to get ashore within ten minutes in spite of heavy artillery and mortar fire. Thus, within a half hour after the initial landing the infantry had full tank support—a record unsurpassed in any previous marine landings in the Central Pacific, except the Marshalls."

Seventeen of the medium tanks had been hit but were able to continue in action. After the troops in succeeding waves disembarked from their LVTs, some of the vehicles were used as ambulances and supply vehicles. The remainder acted as reef patrols to the north against possible Japanese counter landings and for offensive fire missions. Because of losses in LVTs and DUKWs, planned landing of pack artillery was not possible until late in the day.

Fighting was bitter in temperatures reaching 115°F. By night a 3,000 yard beach-head some 500 yards deep had been established. Fierce fighting continued for days and casualties were exorbitantly high. Final Japanese resistance did not stop until November 27.

ROEBLING TRACTORS

The U.S. Marine Corps has as one of its functions the objective of securing beach-heads on hostile soil. The experience of the Allies at Gallipoli in World War I had convinced military men in every country except for a few U.S. Marine officers that the achievement of such an objective no longer was possible. A few amphibious tanks appeared in several countries after World War I but, for the most part, they were screw-driven in water and necessarily fragile and complicated.

The lack of a sound amphibious doctrine prevented the British from either defending or reconquering Norway in World War II. The Germans also never activated Operation Sea Lion following the fall of France because they lacked knowledge and technique. On the other hand, in the years following World War I, the U.S. Marine Corps experimented constantly with ways and means of conducting amphibious assaults. Although the techniques were well developed, search was constant for tools and refinements. This background of firm doctrine made possible the meeting by both the Marine Corps and the U.S. Army of the problems posed by Japanese island defense in the Pacific when the need arose.

One of the tools which was discovered by the Marine Corps was the Roebling tractor. In 1932, Donald Roebling, an engineer and inventor who had retired to Florida for his health, developed a vehicle for rescue purposes during and after hurricanes and to rescue aviators downed in the Florida Everglades, much of which is inaccessible by boat, truck or foot. Roebling felt that there were two essentials required for such a craft—buoyancy and a means of propulsion. His

LVT 1 Prototype undergoing tests at Aberdeen proving ground. (Photo: U.S. Ordnance Dept.)

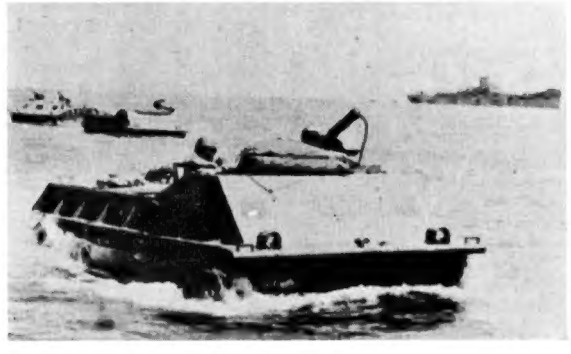
paddle-tread track became the one patented feature of his vehicle. All his vehicles were built of aluminum. He found that the metal was difficult to handle and riveting by conventional means was unsatisfactory. The former was solved by the use of woodworking tools instead of metalworking while the latter was solved by the use of flat cone rivets until a method for welding was found.

The characteristics of a vehicle to travel on both water and land are contradictory. So, as with most vehicles, the resulting design must be a compromise. By official definition in the United States, amphibious vehicles were "those craft whose mode of propulsion is the same on water as it is on land." Thus, Roebling's vehicle had military potential because it was not propelled by screws.

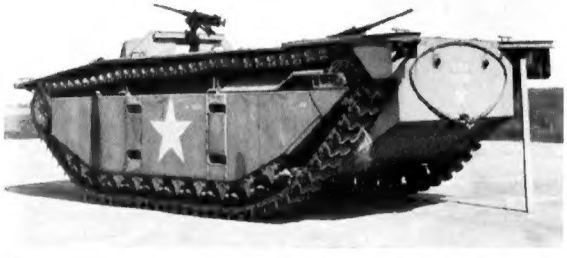
His first machine in 1935 reached a speed of 25 m.p.h. on land but was very slow in water with its straight-across track cleats. Rebuilt in April 1936 to reduce its weight, he added balsa floats and changed to diagonal cleats. Land speed was reduced but water speed doubled. Overhangs front and rear which caused hang-ups on banks were eliminated by another rebuild in September of the same year. Shortening of the vehicle in 1937 reduced the weight still more and improved overall performance.

This model also eliminated the idlers. Rigid bogie wheels were replaced by a chain having built-in roller bearings riding in a smooth steel channel. Water speed now reached nine m.p.h. Further modifications resulted in further weight reduction in 1937 and 1940 but with little effect on speeds and general performance. And, it may be noted in passing that, in spite of a great many subsequent developments, speeds in water for this type of vehicle never have exceeded those of the later Roeblings.

A column of LVT 1s coming ashore at Guadalcanal from supply ships lying offshore. (Photo: U.S. Marine Corps)



LVT 3 with supplementary or bolt-on armor installed over the bow and the side pontoons. (Photo: U.S. Ordnance Dept.)



Three-quarter rear view of LVT 2 armed with ·50 caliber Browning machine-guns. (Photo: U.S. Ordnance Dept.)

Borg-Warner Experimental Model A, the forerunner of the LVT (A) 1 and LVT (A) 4, constructed of aluminum and fitted with M3 Light Tank turret and gun.

LVT 2 showing new W-shaped grousers and Torsilastic suspension system. (Photo: U.S. Ordnance Dept.)

A new Alligator, as all of these vehicles were called, was built in 1940, incorporating everything that had been learned to date. This vehicle was seaworthy and proof against capsizing and it would not sink even with the cargo compartment filled with water. It drew less than three feet of water and was powered by a 95 h.p. Mercury engine. *Life* magazine published a story about it. A Navy admiral called the attention of a Marine general to the article and he, in turn, informed the Major General Commandant who alerted the Chairman of the Marine Corps Equipment Board.

LVT DEVELOPMENT

After investigation, three vehicles were ordered but with Lincoln engines of 120 h.p. Following tests it was decided that this was the vehicle for which the Corps had been searching. An order for 200 was placed in November 1940, but to be fabricated of light steel instead of duralumin. This first vehicle was the LVT 1 delivered in July 1941. Originally intended only for the movement of supplies inland prior to the landing of wheeled vehicles, it was not armored. In practice, it turned out that field commanders were unfamiliar with its shortcomings and demanded too much of it. The few short trips originally intended prior to the arrival of wheeled vehicles invariably ended in continual shuttle service.

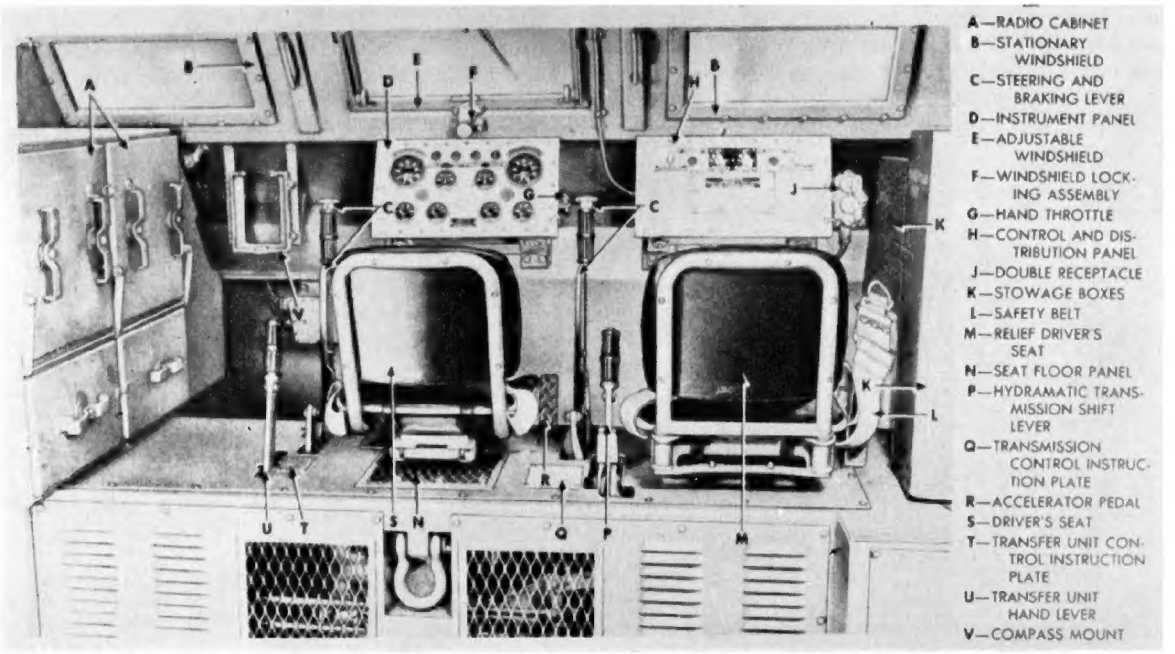
Almost immediately the Marine Corps Equipment Board began working on a design for an armored LVT and the Navy Bureau of Ships began working with Borg-Warner Corporation on a similar design. This latter occurred when the Morse Chain Company Division of Borg-Warner was asked to improve the tracklaying mechanism of the LVT 1.

The LVT 1 never was fully satisfactory mainly because of its track and rigid suspension system. The tracks ran in guides, on the bottom a molybdenum steel channel and on the top a rubber mat. Tracks were thrown easily and the roller bearings corroded in salt water. The LVT 1 gave way to the LVT 2 or Water Buffalo in 1943.

The LVT 2 utilized improved tracks and suspension. Some 47 different grouser faces were tested before the W-shaped face was adopted as standard. These grousers were cast aluminum 2¾ in. high. Grousers wore out rapidly in land use, especially on coral and therefore were bolted on and replaceable. And, because they were readily available and also simplified the problem of spare parts, the M3 Light Tank transmission, Continental engine and final drive were used. The result was a much better vehicle but until drivers could be made to realize the mechanical principles involved in the steering system, a serious fault developed. The brake bands and drums operated in oil. In steering, it was customary to pull on a steering lever not in a steady pull which squeezed out the oil in applying pressure on the drum but by a series of pulls and releases so that the drum would not run dry and freeze. After loading, drivers normally drove in circles while waiting for the entire landing wave to form and kept a steady pull on one steering lever. The result was to freeze the band and drum so that when the time came to form the line, some of the vehicles could not be steered. But with training and practice, this was overcome.

During the initial campaigns in the Pacific the logistical value of the LVT exceeded expectations. As the conflict progressed to the Central Pacific where coral reefs surround tiny islands, the rôle of the LVT changed to tactical. It could cross over coral reefs which kept ships and small craft away and made possible landings independent of local conditions. For tactical use, bolt-on armor was used to make them into armored personnel carriers.

Driver's position in LVT 3 showing location of steering levers and other controls (Protective shield has been removed).
(Photo: U.S. Ordnance Dept.)



It is faintly amusing to mention in passing that the Armored Force Board of the U.S. Army tested an LVT after they had been used in landing operations and solemnly pontificated that "In its present state of development, this vehicle is not suitable for combat." However, it was not long before the Army, of necessity, began to form amphibious tractor battalions just as the Marine Corps had done and to copy training manuals from those of the Marine Corps.

Almost simultaneously with the development of the LVT 2, an armored version with the M3 Light Tank turret and 37 mm. gun was developed. This was the LVT(A) 1. Before an assault, beaches and shore installations were subjected to tremendous naval and air bombardment. But no matter how intense, it never was completely successful. The enemy were usually well entrenched or in caves. When the bombardment was lifted they came out, shook off the numbness caused by the noise and concussion and prepared to repel attack. Thus at the moment it was most needed fire had to be lifted in order to protect friendly troops. The LVT(A) 1 was an attempt to provide a heavier weapon which would bridge the gap following lifting of the preparatory bombardment.

The Borg-Warner firm had designed and built as early as August 1942 their Model A as an outgrowth of the contract with the Navy to improve the tracklaying mechanism of the LVT 1. The Model A was a light-weight vehicle armed with a 37 mm. gun in the M3 Light Tank turret. It had a Cadillac engine and hydramatic transmission and rigid bogie wheels. This experience was drawn upon when the need arose which produced the LVT(A) 1.

At the same time as the LVT(A) 1 was being produced an armored cargo carrier called LVT(A) 2 also was placed in production, principally to meet Army needs. It was the only cargo carrier with an "A" designation. These and the LVT 2 with bolt-on armor became interchangeable as the war progressed.

Up until this time these vehicles had their engines in the rear, restricting cargo space and necessitating loading over the side. The first ramp type LVT was the Borg-Warner Model B in April 1943. This was modified into a T 11 with improved suspension and later into a Model D which became the LVT 3. The Food Machinery Corporation modified an LVT 2 in August 1943 by moving the engine forward and adding a ramp at the rear. This was the prototype of the LVT 4. It could carry 30 men as compared with 18 for the LVT 2. When first used at Saipan in the middle of 1944 it made the earlier LVT 2 and LVT(A) 2 obsolete although these other vehicles of necessity continued in use.

The 37-mm. gun on the LVT(A) 1 was found to be inadequate for the needs and it was augmented by the LVT(A) 4 which used the turret and 75-mm. howitzer of the M8 Howitzer Motor Carriage. It too was first used at Saipan. A year later the howitzer was stabilized and power turret traverse was added, making it the LVT(A) 5, but this version did not see combat during World War II.

Another model intended originally as a cargo carrier appeared in 1945. This was the LVT 3 or Bushmaster. Since large quantities of M5 A1 Light Tank components were available with the obsolescence of that vehicle, their engines and power trains were used for the LVT 3. This model was very effective in its initial employment at Okinawa, the last major campaign in the Pacific, and it continued as the standard post-war model.

After the initial landings on Okinawa the Army LVTs were used for supply. The major portion of the ammunition used on Okinawa came by LVT and DUKW directly from cargo ships lying off shore. The ammunition control officer radioed the ships as to types and quantities of ammunition desired and the vehicles picked up these cargoes and delivered them to the requesters. The operation functioned so well that only about six hours was required from the time a request was made for the ammunition to reach the gun positions.

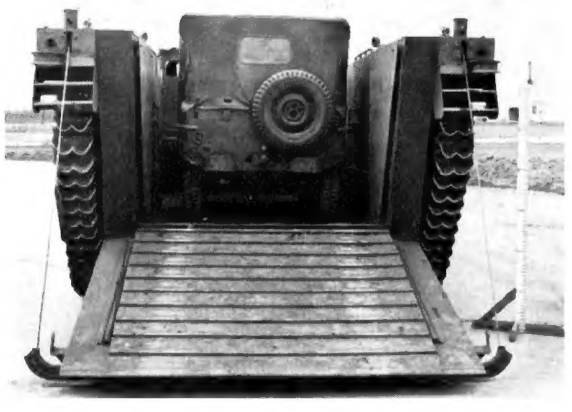
In conjunction with Marine use of LVTs an amphibious wheeled trailer often was drawn singly or in train in order to increase the load-carrying capacity. Many modifications were made in the field in the way of supplementary armor and gun shields until these became available as standard items. Stacks over engine louvers sometimes were added to prevent swamping.

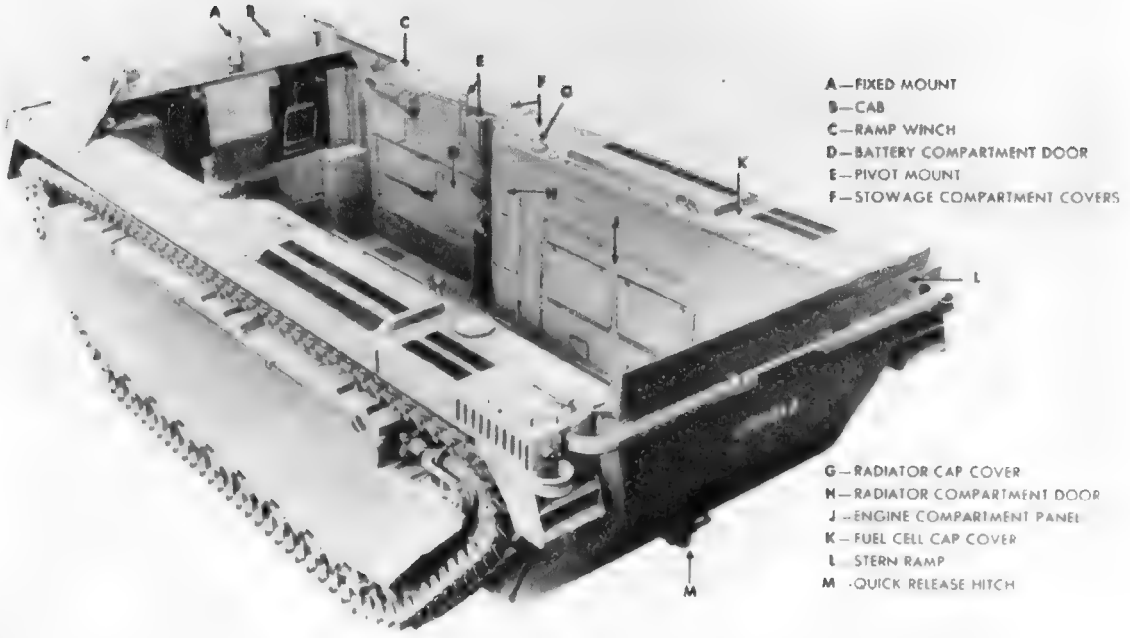
Some LVTs were converted to other uses and became recovery vehicles, shallow water minesweepers, mobile repair shops, command vehicles, wire-layers, carpet-layers, rocket projectors of several types and the flamethrowers already mentioned, as well as a few vehicles which were provided with a special portable ramp used at Tinian to surmount coral cliffs. The Army converted an LVT(A) 1 to a flamethrower unit which was used briefly after the landing on Leyte.

LVTs were used in the following major operations during World War II:

Operation	Date
Guadalcanal, Solomons	August 7, 1942
French Morocco, Africa	November 8, 1942
Attu, Aleutians	May 11, 1943
Shemya, Aleutians	August 15, 1943
Rendova, New Georgia, Solomons	September 1, 1943
Bougainville, North Solomons	November 1, 1943
Tarawa, Gilberts	November 20, 1943
Makin, Gilberts	November 21, 1943
Arawe, New Britain	December 15, 1943
Cape Gloucester, New Britain	December 26, 1943
Kwajalein, Marshalls	February 1, 1944
Namur, Marshalls	February 3, 1944
Roi, Marshalls	February 3, 1944
Eniwetok, Marshalls	February 17, 1944
Emirau, Admiralties	March 20, 1944

LVT 3 with ramp down and loaded with a jeep to illustrate cargo carrying capacity. (Photo: U.S. Ordnance Dept.)



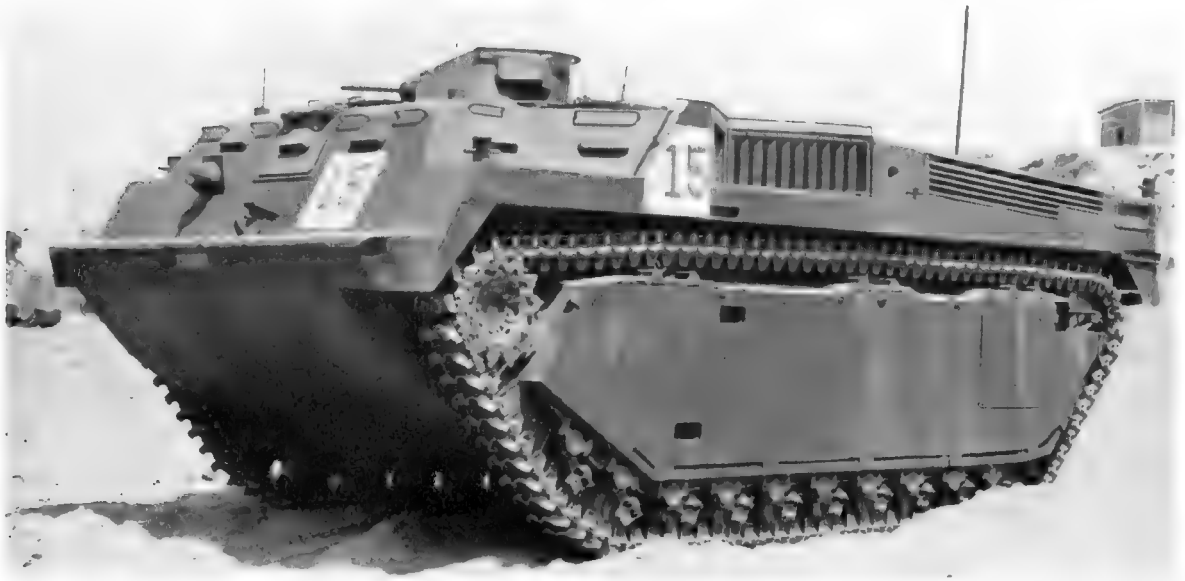


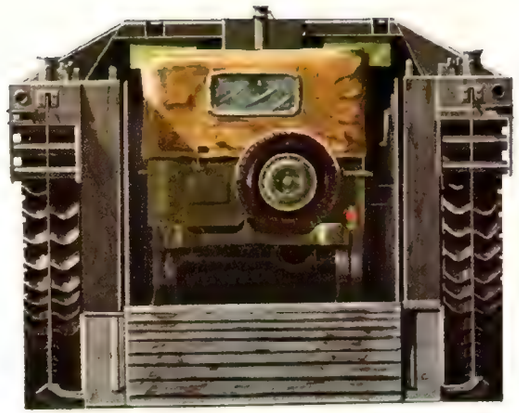
Three-quarter left top view of LVT 3 showing protective plate for driver and with bolt-on armor installed. (Photo: U.S. Ordnance Dept.)

LVT 4 experimentally fitted with a 20 tube 7·2-in. T54 Rocket Launcher. (Photo: U.S. Ordnance Dept.)

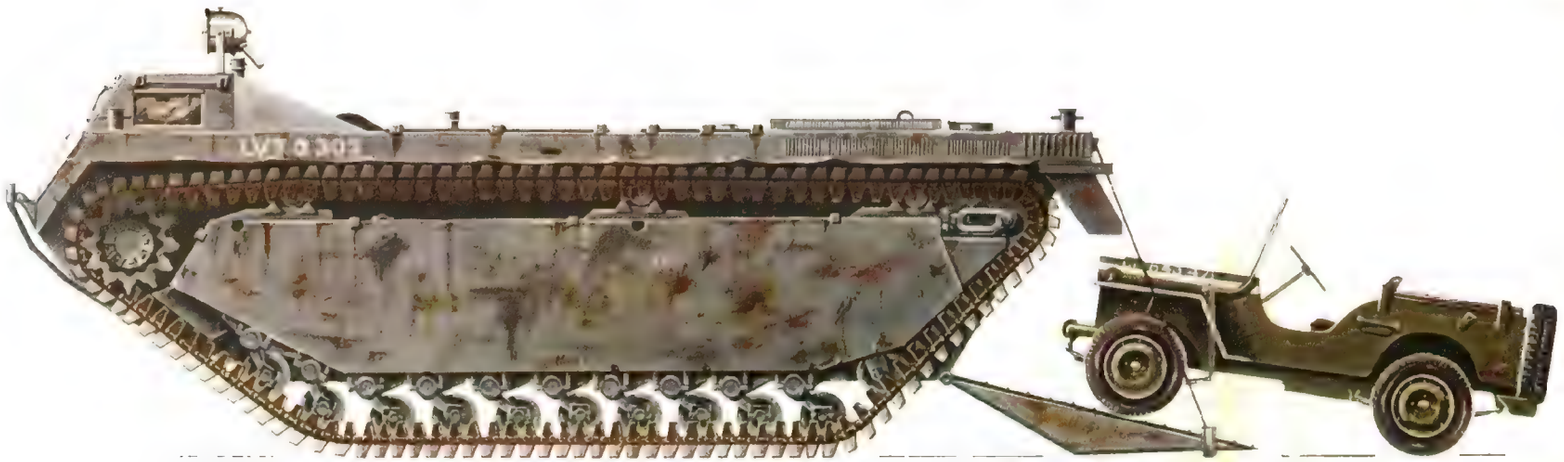
Top view of LVT 3 showing increase in cargo space achieved by placing engines in side pontoons. (Photo: U.S. Ordnance Dept.)

Standard LVT 3C as modified after World War II to cover top and add MG cupola. (Photo: courtesy U.S. Marine Corps)

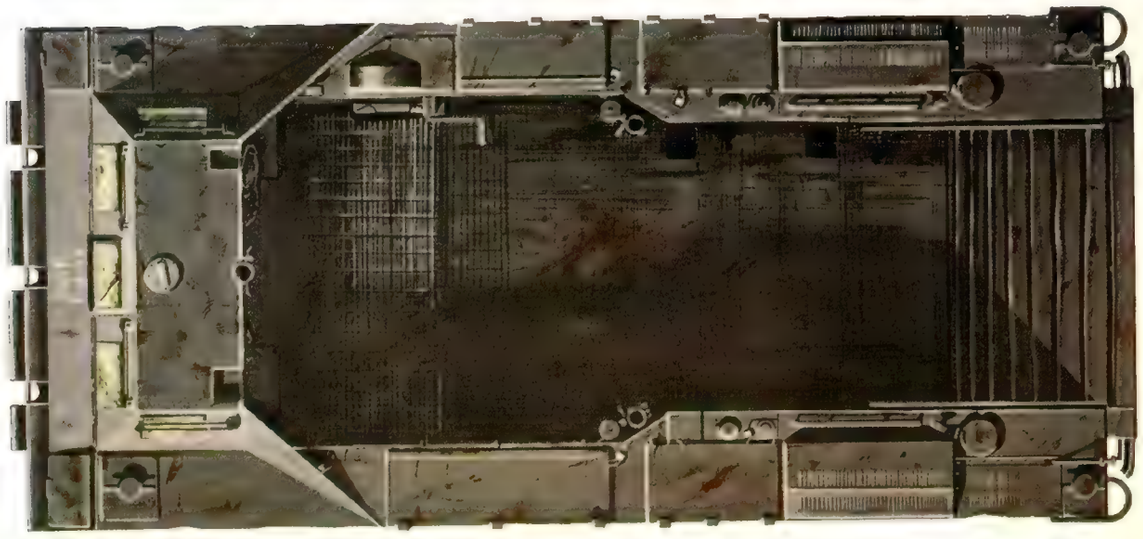




The LVT 2, or Water Buffalo, with .50 Brownings.

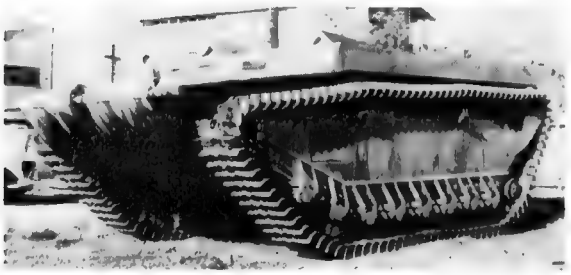


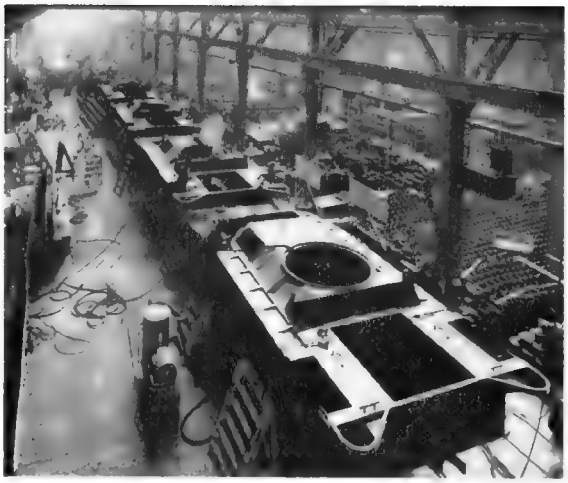
Left-hand page The LVT 3, or Bushmaster. Intended originally as a cargo carrier its engines are in side pontoons thus increasing cargo space. Initially employed at Okinawa, April 1945.



The LVT(A)4 had the turret of the M8 Howitzer Motor Carriage with its 75-mm. howitzer. First used at Saipan, June 1944.

The LVT 3C was the standard post-World War II vehicle used by the U.S. Marine Corps.
(Photo: courtesy U.S. Marine Corps)





LVT (A) 4 vehicles on the assembly line at one of the several plants producing LVTs.
(Photo: Food Machinery Corporation)

Driver's seat in LVT 4 showing difference in location of steering levers as compared with the LVT 3.
(Photo: Food Machinery Corporation)

LVT 4 modified experimentally with new suspension and track with side plates permanently removed.
(Photo: Ingersoll Products Division, Borg Warner Corp.)

LVT 4 modified to carry a 105 mm. Howitzer on standard field carriage. (Photo: U.S. Ordnance Dept.)

Hollandia, New Guinea	April 22, 1944
Biak, New Guinea	May 27, 1944
Saipan, Marianas	June 14, 1944
Naemfoor, New Guinea	July 2, 1944
Guam, Marianas	July 21, 1944
Tinian, Marianas	July 24, 1944
Cape Sansapor, New Guinea	July 30, 1944
Peleliu, Palau, Carolines	September 15, 1944
Moratai, New Guinea	September 15, 1944
Angaur Island, Palau	September 17, 1944
Scheldt Estuary, Europe	October 6, 1944
Leyte, Philippines	October 20, 1944
Belgium	November 8, 1944
Lingayen Gulf, Luzon, Philippines	January 9, 1945
Iwo Jima, Ryukyus	February 19, 1945
Rhine Crossing, Germany	March 7, 1945
Okinawa	April 1, 1945
Mindanao, Philippines	April 17, 1945
Po River, Italy	April 23, 1945
Lake Santerne, New Guinea	April 24, 1945
Bongac Channel, Sulu	April 27, 1945
Cebu, Philippines	May 26, 1945
Balikpapan, Borneo	July 1, 1945

In spite of its shortcomings of low water speed, lack of freeboard, poor maneuverability, limited visibility, thin armor or none, large silhouette, high maintenance requirements and short operating range, the LVT nevertheless proved to be invaluable in the rôles assigned to it.

There had been vehicles other than the Roebling which were intended for use in swamps and marshes. Among these were the Marsh Buggy developed in 1936 by the Gulf Oil Corporation, the Ironcraft Floating Marsh Tractor and several vehicles devised by Higgins Incorporated of New Orleans. All really were wheeled rather than tracklaying vehicles. The Higgins Beachmaster resembled the Roebling but was built on four very large buoyant wheels which propelled the vehicle and kept it afloat. None of these seem to have been considered by the military authorities.

A little known vehicle which resembled the Roebling was one called X-Craft, Salamander or Shillelegh. It was intended to clear paths in minefields on both water and land and to demolish defense installations on beaches. It resembled a stripped-down LVT 2 but was more cheaply built because it was remotely controlled for self-destruction. It could carry 3,000 lb. of explosives. When fitted with an athwartships boom it could tow line-charges or 30-ft.-long bangalore torpedoes to port and starboard to destroy anti-boat mines and underwater obstacles as well as drop markers which showed the paths cleared. It was experimental and only two are known to have existed.

PRODUCTION

LVTs were built by several firms in the United States in addition to Donald Roebling. For the most part they were shipped directly to staging areas or to the field. Average life was estimated initially at 600 hours and average track life at 150 hours. Requirements for production were figured accordingly. In practice it was found that two hours of maintenance were required for every hour of use but the vehicles seldom received it. As a result the attrition was much higher than anticipated and requirements had to be revised upward.

Two LVT 3s and two LVT 4s were produced as lightweight vehicles. By various means weight savings of some four tons were made. Maneuverability was improved but no increase in water speed was achieved.

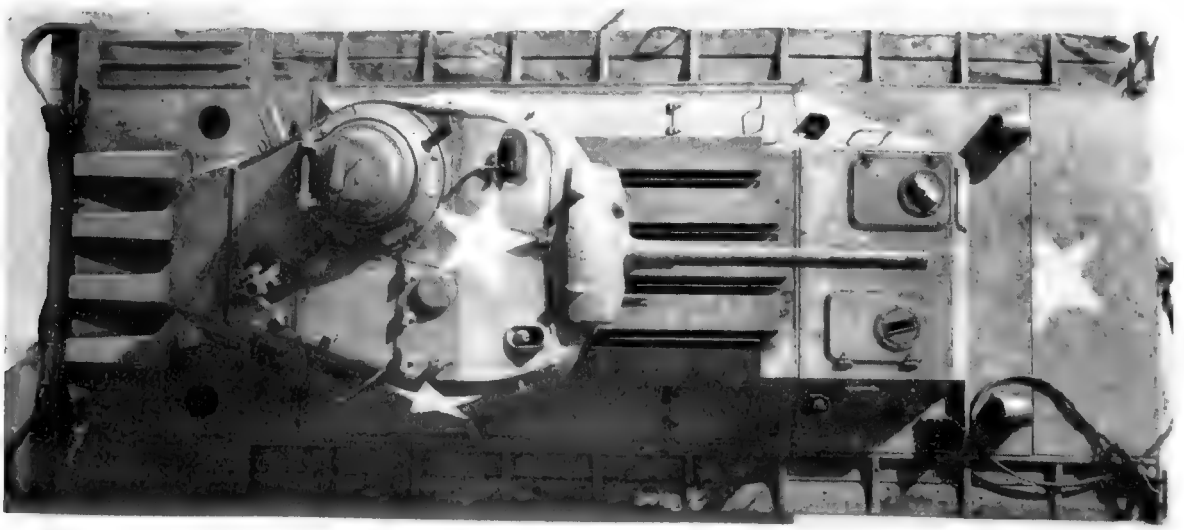
Production by manufacturers was as follows:

LVT PRODUCTION

Model	Built By							Total
	(1) R	(2) FMC	(3) FMC	(4) FMC	(5) GP	(6) ISD	(7) SLC	
LVT 1	X	X	X		X	X	X	1,225
LVT 2		X	X	X	X	X	X	2,963
LVT(A) 1	X		X					509
LVT 3					X	X		2,962
LVT 4		X	X	X	X		X	8,348
LVT(A) 2			X					450
LVT(A) 4			X					1,890
LVT(A) 5			X					269
LVT 3 Lt-Wt						X		2
LVT 4 Lt-Wt				X				2
								18,620

(1) Donald Roebling, Clearwater, Florida
(2) Food Machinery Corporation, Lakeland, Florida
(3) Food Machinery Corporation, Riverside, California
(4) Food Machinery Corporation, San Jose, California
(5) Graham-Paige Motor Corporation, Detroit, Michigan
(6) Ingersoll Steel & Disc Division, Borg-Warner Corporation, Kalamazoo, Michigan
(7) St. Louis Car Company, St. Louis, Missouri

Top view of LVT (A) 1 with M24 Light Tank substituted for M3 Light Tank turret. (Photo: U.S. Ordnance Dept.)



Front view of LVT (A) 1 mounting an M24 Light Tank turret in place of M3 Light Tank turret.
(Photo: U.S. Ordnance Dept.)

LVT (A) 4.

CHARACTERISTICS

With the LVT 1 produced by several manufacturers and with its issue to the field, its shortcomings became apparent resulting in continued minor improvements in the vehicle as well as in methods of manufacture. Similar improvements took place in the later models.

The hull of the LVT 2 had a better shape which continued in later models. The LVT(A) 2 was an armored version of the LVT 2. The LVT(A) 1 was an LVT(A) 2 with the M3 Light Tank turret and 37-mm. gun. The LVT(A) 2 was created initially for the Army. Both the LVT 2 and the LVT(A) 2 differed from all the others in the mounting of its weapons. In these, the forward gun mount was a short rail with a skate mount behind the cab while the after machine-gun was on a skate mount with the rail extending around the sides and rear.

The LVT 3 was a completely new design with a rear ramp. The LVT 4 was the LVT 2 with the engine moved forward and with a stern ramp. A few forward hatch and periscope changes were made in this model as production proceeded. The LVT 3 used a new rubber bushed track. The LVT(A) 4 was identical to the LVT(A) 1 except that the turret was that of the M8 Howitzer Motor Carriage with its 75-mm. howitzer. The LVT(A) 5 was the same as the LVT(A) 4 except that stabilization and power traverse were added.

The U.S. Army might have been expected to retain the Navy designations for the sake of simplicity or at least to apply the familiar T or M numbers. Instead, the old system of designation by Marks was adopted. The LVT 1 became Mark I, the LVT 2 and LVT(A) 2 became Mark II, the LVT 3 became Mark III and the LVT 4 and LVT(A) 4 became Mark IV. The LVT(A) 5 was called Mark V.

Following is a comparative description of the various models:

Item	LVT 1	LVT 2	LVT(A) 1	LVT(A) 2	LVT 3	LVT 4	LVT(A) 4
Engine	Hercules	Continental	Continental	Continental	2 Cadillac	Continental	Continental
No. Cylinders	6	7	7	7	8 each	7	7
Speed (land)	12 m.p.h.	20 m.p.h.	20 m.p.h.	17 m.p.h.	17 m.p.h.	20 m.p.h.	16 m.p.h.
Speed (water)	6 m.p.h.	7·5 m.p.h.	7·5 m.p.h.	6 m.p.h.	6 m.p.h.	7·5 m.p.h.	7 m.p.h.
H.P.	150	250	250	250	220	250	250
Radius (land)	150 miles	150 miles	150 miles	150 miles	150 miles	150 miles	150 miles
Radius (water)	60 miles	100 miles	75 miles	75 miles	75 miles	75 miles	100 miles
Fuels (U.S. gallons)	80	140	140	140	130	140	140
Transmission	—	Spicer	Spicer	Spicer	2 Hydramatic	Spicer	Spicer
Speeds	3F1R	5F1R	5F1R	5F1R	4F1R + 1	5F1R	5F1R
Weight (empty) lbs.	17,300	24,250	29,050	27,600	26,600	27,400	39,460
Weight (loaded) lbs.	21,800	30,250	30,000	35,250	38,600***	36,400	41,000
Length	21' 6"	26' 2"	26' 1"	26' 2"	24' 6"	26' 1"	26' 2"
Width	9' 10"	10' 8"	10' 8"	10' 8"	11' 2"	10' 8"	10' 8"
Height	8' 1½"	8' 2½"	8' 1"	8' 2½"	9' 11"	8' 1"	10' 2½"
Clearance	18"	18"	18"	18"	19"	18"	18"
Hull thickness (max.)	⅜"	14 gauge	½"	½"	14 gauge	14 gauge	½"
Track Shoes	79	73	73	73	103	73	73
Grousers	Curved outward	W shaped	W shaped	W shaped	W shaped	W shaped	W shaped
Track Width	10½"	14½"	14½"	14½"	12"**	14½"	14½"
Track Pitch	3·265"	4⅛"	4⅛"	4⅛"	5½"	4⅛"	4⅛"
Adjustment	Idler blocks	Idler sprocket	Idler sprocket	Idler sprocket	Idler sprocket	Idler sprocket	Idler sprocket
Bogie Wheels	316 rollers	11	11	11	11	11	11
Return rollers	None	2	2	2	2	2	2
Suspension	Rigid	Torsilastic	Torsilastic	Torsilastic	Torsilastic	Torsilastic	Torsilastic
Armored	No	Bolt-on*	Yes	Yes	Bolt-on*	Bolt-on*	Yes
Armament	mg.	mg.	37 mm.	mg.	mg.	mg.	75 mm.
Crew	2-3	2-7	5	2-3	3	2-7	6
Ramp	No	No	No	No	Yes	Yes	No
Remarks				LVT(A) 1 w/o turret		Engine moved forward	LVT(A) 5 same except for power traverse and stabilization

* After March 1944 the cab was armored
** New track with rubber bushings
*** Amount of cargo reduced from 9,000 to 5,300 when bolt-on armor used
Note: Vehicles of the same model varied by manufacturer.
Note: All except the LVT 1 utilized Cleveland differential in the final drive.

DESCRIPTION OF LVT 3

Since the LVT 3 became the standard post-war model, a more detailed description of that vehicle will be given as representative in general of all the wartime vehicles.

The hull of the LVT 3 was divided into the driving compartment and the cargo compartment. The gunners had a step at the front of the cargo compartment just behind the driver's cab. The ramp located at the rear was raised or lowered by means of a hand-operated winch with locks. The ramp portions which came into contact with the vehicle had heavy rubber seals cemented to them in order to provide a water-tight fit.

A pontoon, welded to either side of the hull, housed a Cadillac engine, hydramatic transmission, bilge pumps and a blower to drive out flammable fumes. At the rear of each pontoon was the rear idler used to adjust track tension. At the front of each pontoon was the track driving sprocket. Mounted beneath the pontoons were the bogie wheel suspension assemblies. Sponsons were welded on either side of the hull above the track assemblies and extended the length of the vehicle. A bumper and tow bar assembly were welded on the front of the hull.

Power was transmitted from the hydramatic transmissions (which were in front of the engines) through propeller shafts to right angle drives mounted in the forward ends of the pontoons and thence inboard to the transfer unit and controlled differential assembly. From the controlled differential, power was transmitted by final drive propeller shafts to final drives and drive sprockets mounted in each front corner of the hull.

The hydramatic transmissions provided four forward and one reverse speeds. When travelling forward, the transmission shifted automatically to the several forward speeds. The four forward speeds were grouped into DR and LO speed ranges by means of a selector lever at the driver's right. With the selector lever at DR position, the transmissions would shift forward automatically through the forward speeds as conditions warranted. With the selector lever at LO, automatic shifting was limited to the first and second transmission speeds. A transfer unit also provided a HI, LO and N (neutral) range. The lever for this was at the driver's left.

Bow of LVT (A) 5 in post-World War II modification by Continental Aviation & Engineering Corporation also showing new type of track.
(Photo: Ingersoll Products Division, Borg Warner Corp.)

Grates in the cargo compartment permitted water to drain into the water passages to be removed by the bilge pumps. These water passages were located under the cargo compartment floor. Water passages controlled by flapper type valves also permitted water to drain from the pontoons and from the differential compartment into the water passages under the cargo compartment floor.

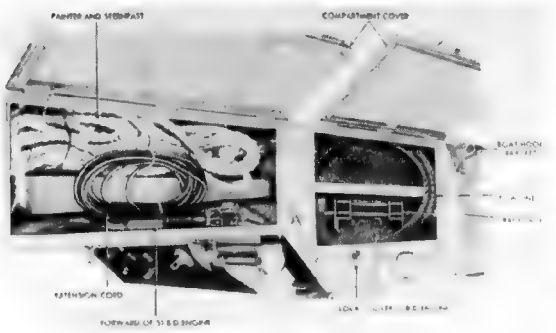
The driver sat in the center of the cab with the co-driver to his right. Three safety glass windows were

LVT (A) 5 with stabilized M8 Howitzer carriage power traverse turret. (Photo: U.S. Ordnance Dept.)

An LVT 4 and an LVT 2 with bolt-on armor pulling a disabled LVT 4 on Leyte Island. (Photo: U.S. Army No. SC 260617)

United States Marine Amtracs or LVTs hitting the beach at Guam in the Pacific. (Photo: courtesy U.S. Marine Corps)

An LVT (A) 2 being detrucked from an M26 "Dragon Wagon" tank transporter at Roermond, Holland.
(Photo: U.S. Army No. 202365)



View of the starboard stowage compartments with covers open on the LVT 3. (Photo: U.S. Ordnance Dept.)

The LVT 3 fitted with Ronson Flamethrower was of considerable use on Peleliu.

provided in the front of the cab. There were two side windows, one on either side. The middle front window was an escape hatch hinged at the top and could be opened for ventilation. A steel protective shield was located behind the driver's back. An instrument panel was in front of the driver and a radio was to his left. Two steering brake levers were located in front of the driver, one on either side, and used for steering and braking. The accelerator pedal was located on the floor in front of the driver's right foot. There also was a hand throttle on the right of the instrument panel. Both engines were controlled as a unit by means of suitable linkage.

An independent CO2 fire extinguisher was provided for each engine compartment with a release lever on the top of each valve release head. Remote control fire pull handles were mounted in protective depressions in the cargo compartment bulkheads on either side.

The vehicle was provided with a portable signalling searchlight and trouble light. The searchlight was mounted above the cab at the right rear and was fitted with an extension cord so that it could be removed and used anywhere in the vehicle. An interesting provision was a wooden box mounted on the right side of the cab. It contained waste and tapered wooden plugs of various sizes stowed in a canvas bag to be used for stopping leaks in the hull when travelling in water.

A stowage compartment was located in each sponson above the engines. In these were stowed painters, tools of various sizes and a five gallon fresh water container. There also were spare parts packed in a box strapped to the gunner's platform behind the cab.

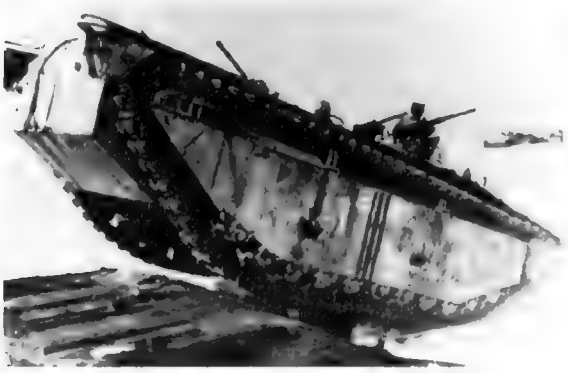
As issued, two caliber 0·30 machine-gun mounts were located on pivot shafts on the left and right forward sponsons. A caliber 0·50 machine-gun mount was located at the center rear of the cab. However, in practice, in addition to these weapons, others sometimes were added and sometimes shields were added in the field. These varied in design but later in the war they were furnished with the bolt-on armor in uniform pattern.

The torsilastic or rubber torsion suspension comprised a hollow shaft with rubber vulcanized between it and another hollow shaft of larger diameter so that the inner shaft could be anchored to the hull. The outer shaft had wheel arms between which the bogie wheel arms were mounted. As the vehicle negotiated irregular terrain the outer shaft twisted on the inner shaft with the natural resistance of the rubber acting as a spring of sorts. The two tubes combined became in effect a solid torsion bar.

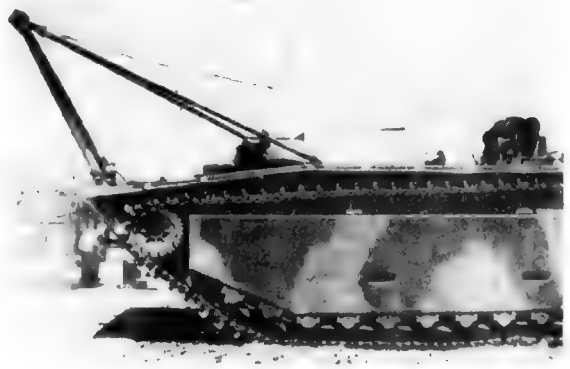
The tracks on the LVT 3 differed from those on the other models in that they were rubber bushed whereas the others were of the dry pin type. Even moderate wear on the dry pin tracks caused elongation and consequent throwing. Rubber bushing eliminated much of this. There were 103 track plates per side as compared with the others having 73. The tracks were only 12 in. wide compared with 14¼ in. in the others while the pitch of the LVT 3 tracks was a little over an inch greater. Nevertheless the LVT 3 functioned as well or better in spite of the narrower tracks.

The early LVTs were painted with aluminum or a

An LVT 2 going down the ramp of a landing craft to take to the water.



The LVT (R), an improvised recovery vehicle, fitted with A-Frame and winch. (Photo: courtesy G. N. Vulgaris)



Some LVTs were fitted with built-up superstructures and three-sided shield for machine-guns.

Another type of shield for LTV armament was common.
(Photo: U.S. Marine Corps)

light blue paint. Later vehicles were painted a slate blue color. Eventually the standard battleship gray was used, at least by the Marine Corps although occasionally some appeared in old Army olive drab. The Army used both the standard old and the later new standard olive drab. However, at Bougainville and Leyte, Army vehicles were seen painted in conventional camouflage dazzle patterns.

THE INCHON LANDING

After the war, in 1949, the LVT 3 was modernized by adding an armored cover over the cargo compartment together with a small turret with a machine-gun. The LVT(A) 5 also was modernized by the addition of a cover for the turret, and a false bow, rounded for greater buoyancy and better performance in the water, was added.

These vehicles were used in the famous Inchon landing in Korea in 1950. The North Korean attack in June of that year had forced the United Nations forces southward into the Pusan perimeter where its strength slowly was increased and where from August 6 to September 15 the North Koreans were unable to effect a breakthrough. The initiative abruptly changed hands on that date when the United Nations forces made a successful landing more than 150 miles behind North Korean lines.

In mid-July General Douglas MacArthur had started his staff planning a strategic water-borne envelopment. To quote from *Operations in Korea*, a West Point textbook, "Landings at Kunsan, Wonson, Inchon and elsewhere were considered. A landing at Inchon would involve practically every disadvantage known to amphibious specialists. There was an unusual tidal range of over twenty-nine feet which would permit use of the beaches for only about three hours in twelve; at low tide there was a wide expanse of mud flats in front of the difficult beaches; the channel was narrow and the port facilities inadequate. But a landing at Inchon had the prime strategic advantage of proximity to Seoul, which lay astride the major north-south supply arteries. Other favorable considerations were Seoul's psychological importance as South Korea's capital city and its value to the enemy as a supply base. Intelligence estimates indicated the area was comparatively lightly defended.

"Despite the grave risk, General MacArthur, with the approval of the Joint Chiefs of Staff, decided that the amphibious assault would be made at Inchon. He also insisted that the operation take place on September 15, the earliest date on which the tides would be suitable.

"For purposes of deception, ROK marines made a minor landing at Mokpo on the southwest coast and executed feints at Kunsan on the west coast and near Pohang and Yongdok on the east coast. Naval forces conducted a demonstration off Samchok.

"Preceded by a two day naval air and gunfire preparation, the landing force, consisting of the newly formed X Corps (7th Army and 1st Marine Divisions), moved into the transport area.

"The plan for the first phase of the operation required the seizure of Wolmi, a tiny island which dominates Inchon harbor and which is connected to the port of Inchon by a causeway. At dawn on September 15, about one hour before high tide, a reinforced battalion of the 1st Marine Division landed and captured Wolmi against light resistance in less than thirty minutes.

"The second phase contemplated the seizure of the Inchon Peninsula. During the next high tide, at 1730 hours, other elements of the 1st Marine Division assaulted the nine-foot sea wall in the port area. North Korean garrison and security forces offered little opposition . . . The 7th Infantry Division came ashore on September 18 . . . on the south flank. . .

"The third phase contemplated the liberation of Seoul and the denial to the enemy of the railroads and highways in the vicinity, which fed his forces in the

Curved gun shields were in common use on the early LVTs.
(Photo: U.S. Marine Corps)

south. . . Fanatical enemy resistance in and around the capital confronted the columns advancing from north, south and west; however, Seoul fell on September 26."

POST-WAR LVT DEVELOPMENT

At the same time as the Korean War was going on design developments continued in the United States. Many prototype vehicles were built after World War II, culminating late in 1950 in the LVT(P) 5 and LVT(H) 6 programs. The LVT(P) 5 and LVT(H) 6 had the ramp in the bow instead of the stern, a V-bow, an inverted V-bottom and a new underwater return track system. These vehicles weighed twice as much as the wartime LVTs but were much more stable in the water and doubled the land speed of their predecessors. Variations included a recovery vehicle, the LVT(R)-X 1; a command vehicle; AA vehicles LVT(AA)-X 1 and X 2 and an engineer vehicle, the LVT(E)-X 1. These are the vehicles currently in use.

Since then, Navy and Marine Corps experiments have continued with Rolligan type vehicles and hydrofoils. The Army after World War II experimented with conversions of the M18 Gun Motor Carriage into the screw-driven T86 and T87, the M59 and M75 APC and finally the M113 and M114 APC vehicles.

Post-war experiments included the following:

LVT (Winterized) with Double Tracks
LVT 4 with 22-in. Track
Borg-Warner 15-ton Carrier
Aluminum Lightweight Carrier
Aluminum 76-mm. Gun Carrier
M24 Light Tank Turret on LVT(A) 4
LVT(U)-X 1, a huge cargo carrier
LVT(U)-X 2, similar
LVT(P)-X 1, an armored personnel carrier
LVT(P)-X 2, similar to the Army M59
LVT(P)-X 3, a personnel carrier
LVT Prototype A, a 105-mm. howitzer carrier
LVT 3 Universal Carrier
LVT(H)-X 4, a 105-mm. howitzer carrier
LVT(P) 6, similar to LVT(P) 5

The LVT (F) or Sea Serpent, an American LVT 4 fitted by the British with two wasp flame-throwers and one Browning machine-gun. (Photo: courtesy B. T. White)

These experiments were carried on by Baldwin-Lima-Hamilton Corporation, Continental Aviation and Engineering Corporation, Marmon-Herrington Company, Pacific Car and Foundry Company, Ingersoll-Kalamazoo Division of Borg-Warner Corporation and Food Machinery Corporation. Of these, only Pacific Car and Foundry and Food Machinery Corporation have continued in the field. The latest vehicles are the XM 701 and LVT(P)-X 12 respectively.

During World War II, LVTs were furnished to Nationalist China, to Britain and to Free French forces. After the war, France, Italy, the Netherlands, South Korea and Thailand received some. Known French modifications included an LVT 4 with a 40-mm. Bofors gun in a low turret and an LVT(A) 5 converted to a command vehicle. The Red Chinese continued to use some of the vehicles captured from the Nationalist Chinese.

The British modified some of their vehicles into rocket carriers, the LVT(R), the Sea Serpent (Wasp flamethrower) and carpet-layers. In addition to the American vehicles used by the British Army, two English designs appeared during the war, one closely resembling the American design. The latter was the Neptune, the former the Argosy. The Argosy more closely resembled the German Landwasserschlepper. The Neptune existed in several variations for specific combat rôles.

British Amphibian, tracked, 2T G, 5 (LVT (A) 2), armed with 20 mm. Polsten cannon. (Photo: courtesy V. Poelman de Arabandere)

SPECIFICATION: LVT 3

Length overall	24′ 2½″
Width overall	11′ 1″
Height loaded	
Cab	8′ 5″
Cal·50 mount	8′ 11½″
Stern ramp	8′ 1½″
Height unloaded	
Cab	8′ 5½″
Cal·50 mount	9′ 0″
Stern ramp	8′ 2″
Draft (to bottom of grousers) unloaded	52″
Draft (to bottom of grousers) loaded	59″
Track width	12″
Track pitch	5½″

Crew: 3, driver, radio operator, mechanic

	Weight in pounds			
	Without Portable Armor	With Portable Armor	With Armored Cab without Portable armor	With Armored Cab with Portable armor
Bare weight	26,600	29,600	27,800	30,000
With crew and fuel	29,600	32,600	30,300	32,500
Loaded	38,600	38,600	38,600	38,600

Ground pressure	
Bare weight	8·2 p.s.i.
With crew and fuel	10·2 p.s.i.
Loaded	12·8 p.s.i.
Ground contact	3,130 sq. in. (2¾ in. penetration)
Clearance (fully loaded	19″
Clearance (hard ground)	19″
Clearance (soft ground)	16¼″
Approach angle	35°
Departure angle	30°
Gradeability (loaded)	35° or 70%
(unloaded)	35° or 70%
Side hill operation	30° or 58%
Climbing ability	38½″
Cruising range	10 hours, 115-150 miles on land, 50 miles on water

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Nationalist Chinese Marines on maneuvers debarking from an LVT 4 which has roof cover and hatches.
(Photo: courtesy U.S. Marine Corps)

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